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Difference of Serum Vitamin D Levels in Government Employees with Hypertension and Without Hypertension in Kupang City

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Hypertension; Vitamin D; Government Employees

Abstract

Vitamin D deficiency has been widely recognized as a global public health concern and is increasingly associated with cardiovascular diseases, including hypertension. This study aimed to compare serum vitamin D levels between government employees with hypertension and those without hypertension in Kupang City, Indonesia. A cross-sectional design was employed involving 60 government employees, divided equally into hypertensive and non-hypertensive groups. Data were collected through structured interviews, physical examinations, and laboratory analysis of serum vitamin D levels using the Enzyme Chemiluminescence Immunoassay (ECLIA) method. Statistical analysis was conducted using the independent t-test and the Mann–Whitney U test, with a significance level of $p < 0.05$. The results showed that the mean serum vitamin D level in the hypertensive group (25.91 ± 8.50 ng/mL) was significantly lower than in the non-hypertensive group (29.91 ± 5.01 ng/mL), with a p-value of 0.002. Additionally, hypertensive respondents had a higher body mass index and older age compared to non-hypertensive participants, both of which were statistically significant. These findings indicate a potential association between lower vitamin D levels and the presence of hypertension among government employees. In conclusion, serum vitamin D levels were significantly lower in individuals with hypertension, suggesting that vitamin D may play a role in blood pressure regulation. Further longitudinal and interventional studies are recommended to determine causality and evaluate the potential benefits of vitamin D supplementation in hypertension prevention and management.

INTRODUCTION

Vitamin D deficiency is a global health issue, affecting up to one billion people worldwide. The global prevalence of vitamin D deficiency (<30 nmol/L) between 2000 and 2022 was 15.7%, although it varies across different regions. The highest prevalence of vitamin D deficiency (<30 nmol/L) is found in the Eastern Mediterranean region, with Kuwait reporting a prevalence of 58.9%, while the lowest prevalence is in the Americas region, at 3%. In Europe, the prevalence of vitamin D deficiency (<30 nmol/L and <50 nmol/L) is 18% and 53%, respectively (Cui et al., 2023). Japan, as one of the developed countries in Asia, has a prevalence of vitamin D deficiency (<50 nmol/L) of 53.6%. The prevalence of vitamin D deficiency in Southeast Asia ranges from 6% to 70%. In Malaysia, the prevalence of vitamin D deficiency (<50 nmol/L) was 67.9% in 2011, while in Thailand, the prevalence among pregnant women was 34% in 2015.2,3 In Indonesia, a study conducted by Octavius et al. (2023)

found that 63% of pregnant women aged 27.6 to 30.6 years had vitamin D deficiency (Octavius et al., 2023).

Vitamin D is primarily known for its classic role in maintaining calcium and phosphate homeostasis. However, advances in science have revealed the presence of vitamin D receptors in nearly 30 different tissues beyond bone, including the gut, kidneys, heart, immune system, and adipose tissue. This knowledge expands our understanding that vitamin D exerts pleiotropic effects on various body systems. When vitamin D deficiency occurs, not only is calcium and phosphate balance disrupted, but other physiological systems—including the cardiovascular system—may also be affected, contributing to the development of non-communicable diseases (NCDs).5 Non-communicable diseases (NCDs) are chronic, non-infectious diseases that cannot be transmitted from person to person or from animals to humans (Kemenkes RI, 2013).NCDs include cardiovascular diseases, cancers, chronic respiratory diseases, and others. According to World Health Organization (WHO) data from 2016, NCDs accounted for 71% of total global deaths, with cardiovascular diseases contributing to 44% of all NCD-related deaths. In Indonesia, cardiovascular disease accounted for 35% of total deaths in 2016 (World Health Organization, 2018). One of the major risk factors for cardiovascular disease is hypertension (Ciumărnean et al., 2022).

Hypertension is most prevalent in lower-middle-income countries, including Indonesia. Based on physician diagnoses, the prevalence of hypertension among individuals aged ≥18 years in Indonesia is 8.6%, while measurements indicate a prevalence of 30.8%.7,9 In East Nusa Tenggara Province, the prevalence of hypertension among individuals aged ≥18 years is 6.8% based on physician diagnoses and 28.2% based on blood pressure measurements. By occupation, the second-highest prevalence of hypertension occurs among government employees (civil servants, military, police, and employees of state- or region-owned enterprises), with a prevalence of 10.9% based on physician diagnoses and 32.4% based on measurements (Kementerian Kesehatan, 2023). The high prevalence of hypertension among civil servants is supported by studies conducted by Darmadi et al. (2013) and Sabila et al. (2024), which demonstrated significant associations between hypertension and factors such as work-related stress, workplace diet, sleep quality, and exercise habits (Darmadi et al., 2013**;** Sabila & Sari, 2023). A study conducted by Mokhtari et al. (2022) revealed that low vitamin D levels are associated with an increased incidence of hypertension in adults (Mokhtari et al., 2022). Similarly, research by Priya et al. (2017) found that low vitamin D levels were associated with higher systolic blood pressure and showed significant differences in vitamin D levels between the control group (normal blood pressure) and the case group (hypertension) among individuals aged 18 to 50 years (Priya et al., 2017). Experimental research by Dalbeni et al. (2014) also demonstrated that vitamin D treatment for 25 weeks reduced systolic blood pressure in patients with chronic heart failure, supporting the link between vitamin D and hypertension (Dalbeni et al., 2014). However, these findings contrast with studies such as that of Witham et al. (2014), which found that high-dose vitamin D supplementation did not reduce blood pressure in patients aged ≥18 years with resistant hypertension (Witham et al., 2014). Likewise, a 2015 study by Arora et al. reported that vitamin D supplementation did not lower blood pressure in individuals aged 18 to 50 years with prehypertension or grade 1 hypertension (Arora et al., 2015).

Given the high prevalence of hypertension among civil servants, military, police, and employees of state- and region-owned enterprises, as well as the inconsistent findings regarding the role of vitamin D in blood pressure regulation, this study aims to compare serum vitamin D levels between government employees with and without hypertension working at the *Dinas Perhubungan Provinsi Nusa Tenggara Timur, Dinas Perhubungan Kota Kupang, Badan Pusat Statistik, Dinas Perumahan Rakyat dan Kawasan Permukiman, and Badan Keuangan dan Aset Daerah Kota Kupang.*

METHOD

This study employed a cross-sectional research design with consecutive sampling. A total of 60 respondents participated in the study, divided into two groups: those with hypertension and those without hypertension. The respondents were government employees from the Dinas Perhubungan Provinsi Nusa Tenggara Timur, Dinas Perhubungan Kota Kupang, Badan Pusat Statistik, Dinas Perumahan Rakyat dan Kawasan Permukiman, and Badan Keuangan dan Aset Daerah Kota Kupang. Data collection was conducted in stages from September 3, 2024, to November 4, 2024.

The inclusion criteria were as follows: respondents were government employees; subjects without hypertension had never been diagnosed with hypertension and had not previously taken antihypertensive medication; and subjects with hypertension had blood pressure ≥140/90 mmHg or a history of being diagnosed with hypertension by a physician and were currently taking antihypertensive medication. The exclusion criteria included individuals with a history of gestational hypertension, those who were pregnant, and those who had consumed vitamin D supplements within the past three months. The independent variable in this study was serum vitamin D level, while the dependent variable was blood pressure status. Confounding variables included age, sex, obesity, smoking habits, and alcohol consumption.

Data were collected through structured interviews, physical examinations (including blood pressure and body mass index measurements), and laboratory analysis of serum vitamin D levels from venous blood samples using the Enzyme Chemiluminescence Immunoassay (ECLIA) method. Blood pressure measurements were conducted according to the International Society of Hypertension (2020) guidelines using a validated digital sphygmomanometer, with three measurements taken at one- to two-minute intervals and the mean of the last two readings recorded. Data analysis was performed using SPSS version 26.0. The normality of data distribution was assessed using the Shapiro–Wilk or Kolmogorov–Smirnov test, homogeneity was tested with Levene's test, and differences in serum vitamin D levels between groups were analyzed using the independent t-test or Mann–Whitney U test, depending on data distribution. A p-value of less than 0.05 was considered statistically significant.

This study was conducted after obtaining ethical approval from the Ethics Commission of the Faculty of Medicine, Nusa Cendana University (Registration No. UN01240760).

RESULTS AND DISCUSSION

A total of 60 respondents participated in this study from several government offices in Kupang City, East Nusa Tenggara. The majority of respondents were from Dinas Perhubungan Provinsi Nusa Tenggara Timur, comprising 19 individuals (31.7%). Respondents were divided into two groups: 30 with hypertension (50%) and 30 without hypertension (50%). All

respondents were within the productive age range of 18–59 years, with the largest proportion in the 46–55-year age group (35%). Male respondents predominated, accounting for 42 individuals (70%). Most respondents fell into the vitamin D insufficiency category, with 33 individuals (55%). Based on nutritional status, 25 respondents (41.7%) were classified as having obesity class I. The majority of respondents were non-smokers (68.3%) and did not consume alcohol (66.7%). The detailed characteristics of the respondents are presented in Table 1.

Cardiovascular diseases are a group of disorders affecting the vascular system and the heart and are classified as non-communicable diseases. Cardiovascular disease is the leading cause of death worldwide. Risk factors for cardiovascular disease include hypertension, dyslipidemia, diabetes mellitus, smoking behavior, age, and obesity.

Table 1. Basic characteristics of the respondents

Characteristics	Hypertension		Non-Hypertension		Mean Serum Vitamin D	Total	
	n	%	n	%	ng/mL	n	%
Sex							
Male	18	60	24	80	30,5	42	70
Female	12	40	6	20	21,9	18	30
Age (years)							
18-25	1	3,3	1	3,3	23,8	2	3,3
26-35	6	20	11	36,7	25	17	28,3
36-45	5	16,7	12	40	31,6	17	28,3
46-55	15	50	6	20	27	21	35
56-59	3	10	0	0	32,2	3	5
Vitamin D Status							
Sufficient (≥30 ng/mL)	8	26,7	13	43,3		21	35
Insufficient (21-29 ng/mL)	16	53,3	17	56,7		33	55
Deficient (≤20 ng/dL)	6	20	0	0		6	10
BMI Status							
Underweight	1	3,3	0	0	16,9	1	1,7
Normal	1	3,3	8	26,7	26,3	9	15
Overweight	4	13,3	6	20	29,97	10	16,7
Obesity 1	14	46,7	11	36,7	28,53	25	41,7
Obesity 2	10	33,3	5	16,6	25,3	15	25
Smoking Status							
Merokok	5	16,7	14	46,7	31,38	19	31,7
Tidak Merokok	25	83,3	16	53,3	26,3	41	68,3
Alcohol Consumotion Status							
Consumes Alcohol	5	16,7	15	50	31,68	20	33,3
Does Not Consume Alcohol	25	83,3	15	50	26	40	66,7
Workplace							
Dishub Kota Kupang	5	16,7	10	33,3	33,36	15	25
Dishub Provinsi NTT	11	36,7	8	26,7	26,8	19	31,7
Dinas PRKP Kota Kupang	3	10	7	23,3	25,96	10	16,7
BPS Provinsi NTT	10	33,3	5	16,7	25,25	15	25
BKAD Kota Kupang	1	3,3	0	0	26,6	1	1,7
Total	30	100	30	100	27,9	60	100

Hypertension, as one of the major risk factors for cardiovascular disease, is determined based on blood pressure measurements. The measurement should be taken from at least two readings, and the average value is used. Hypertension is diagnosed when the average systolic blood pressure (SBP) is ≥140 mmHg and/or diastolic blood pressure (DBP) is ≥90 mmHg.[17] Similarly to age, the higher a person's blood pressure, the greater their risk of developing cardiovascular disease.

In this study, all respondents were government employees working in several offices in Kupang City. Based on data from the 2023 Indonesian Health Survey, government employees have the second-highest prevalence of hypertension after the unemployed population. A study conducted by Sabila et al. (2023) found a significant relationship between age, sodium intake, fat intake, physical activity, and sleep quality with the incidence of hypertension among civil servants. These findings are consistent with research by Darmadi et al. (2013), which reported a significant relationship between work stress, workplace diet, and exercise habits among civil servants.

Table 2. The Difference between Serum Vitamin D Level, BMI, and Age among Government Employees with and without Hypertension in Kupang City

Variabel	Hypertension (n=30)		Non Hypertension (n=30)		*p* Value
	Mean ± SD	Med (min;max)	Mean ± SD	Med (min;max)	
Serum Vitamin D (ng/mL)	25,91 ± 8,50	23,85 (13,7;48,1)	29,91 ± 5,01	29,5 (23,6;40,6)	0,002[a]*
BMI (Kg/m^2)	28,96 ± 5,23	28,7 (16,8;41,5)	25,81 ± 3,92	25,64 (20,2;34,8)	0,011[b]*
Age (years)	44,67 ± 9,6	47,5 (23;58)	38,37 ± 7,79	38,0 (22;55)	0,003[b]*

aMann-Whitney test
bIndependent t-test
*significant with p value < 0,05

In this study, the age difference between the hypertensive and non-hypertensive groups was statistically significant, with a p-value of 0.003 ($p < 0.05$). The mean age of respondents with and without hypertension was 44.67 and 38.37 years, respectively. This supports the theory that hypertension is an age-dependent disease. The aging process is associated with an increased prevalence of metabolic syndrome, inflammation, and neurohormonal disturbances. These conditions cause endothelial dysfunction, increase matrix metalloproteinases (MMPs), reduce elastin, and increase collagen and calcification, leading to arterial stiffness. Arterial stiffness subsequently contributes to hypertension due to the dysregulation of vascular resistance (Sun, 2015).

There was also a significant difference in mean Body Mass Index (BMI) between the hypertensive and non-hypertensive groups ($p = 0.011$, $p < 0.05$), with mean BMI values of 28.9 and 25.8 kg/m², respectively. These results are consistent with those of Landi et al. (2018), who found that the BMI of hypertensive respondents (26.7 kg/m²) was significantly higher than that of non-hypertensive respondents (24.1 kg/m²), with a p-value < 0.001 ($p < 0.05$). Although the

exact mechanism linking obesity and hypertension is not fully understood, chronic inflammation in obese individuals is believed to play a key role. Adipocytes are prone to lipolysis, producing adipokines and other pro-inflammatory cytokines, which reduce nitric oxide activity—a molecule important in regulating vascular tone and suppressing vascular smooth muscle proliferation (Landi et al., 2018).

Multiple factors contribute to hypertension, including smoking habits, diet, obesity, age, and vitamin D deficiency (Al-Ishaq et al., 2021; Dikalov et al., 2019; Sun, 2015). Vitamin D is currently considered one of the risk factors for hypertension. Various studies have demonstrated a relationship between vitamin D deficiency and the incidence of hypertension. Animal studies by Jia et al. (2021) found that rats lacking vitamin D receptors (VDR) had higher blood pressure compared to control rats (Jia et al., 2022).

In this study, the mean serum vitamin D level among all respondents was 27.91 ng/mL. This value is relatively higher compared to several previous studies conducted in Indonesia, such as the study by Vera et al. (2015), which reported an average serum vitamin D level of 35.4 nmol/L (14.2 ng/mL) among women aged >50 years (Vera et al., 2015). Pinzon et al. (2020) also reported an average vitamin D level of 10.97 ng/mL in COVID-19 patients.25 The higher values observed in this study may be due to respondents' tendency to wear short-sleeved clothing during work and the predominance of male participants (70%).

The 56–59-year age group had the highest mean serum vitamin D level (32.2 ng/mL), while the 18–25-year age group had the lowest (23.8 ng/mL). This finding contrasts with the study by Giustina et al. (2023), which proposed that serum vitamin D levels decrease with age (Giustina et al., 2023). Low serum vitamin D levels in younger respondents may result from limited sun exposure, sunscreen use, and wearing long-sleeved clothing (Holick et al., 2011).

In this study, the overweight group had the highest mean serum vitamin D level (29.97 ng/mL), while the underweight group had the lowest (16.9 ng/mL). This finding contradicts the general understanding that vitamin D levels are inversely related to obesity. Vitamin D deficiency may occur in obese individuals because vitamin D tends to accumulate in adipocytes, and animal studies have shown decreased CYP2R1 enzyme activity in obese mice (Bennour et al., 2020).

The bivariate analysis showed a significant difference in serum vitamin D levels between the hypertensive and non-hypertensive groups ($p = 0.002$, $p < 0.05$), with mean values of 25.9 ng/mL and 29.9 ng/mL, respectively, and a mean difference of 4 ng/mL. These results align with those of Priya et al. (2017), who reported similar findings among 201 respondents (102 hypertensive and 99 non-hypertensive). An independent t-test revealed a p-value of 0.0001 ($p < 0.05$), indicating a significant difference in serum vitamin D levels between the two groups. In that study, the mean serum vitamin D level was 15.15 ng/mL in the hypertensive group and 33.59 ng/mL in the non-hypertensive group, with a mean difference of 18.44 ng/mL.

Similarly, Kar et al. (2018) found significant differences between the two groups, with mean serum vitamin D levels of 22.36 ng/mL in hypertensive and 27.57 ng/mL in non-hypertensive respondents ($p = 0.018$, $p < 0.05$).29

Priya et al. (2017) also reported a significant relationship between serum vitamin D levels and systolic blood pressure ($p = 0.01$, $p < 0.05$).13 Likewise, Hermawan and Andoko (2019) demonstrated a significant relationship between serum vitamin D levels and the incidence of hypertension among the elderly (Hermawan, 2019). This suggests that vitamin D plays a role

in blood pressure regulation. Supporting this, Chen et al. (2022) found that vitamin D supplementation lowers blood pressure in hypertensive patients with vitamin D deficiency but is ineffective in normotensive subjects with sufficient vitamin D levels (Chen et al., 2022).

Although many studies show significant differences in serum vitamin D levels between hypertensive and non-hypertensive individuals and report that vitamin D supplementation lowers blood pressure in deficient hypertensive patients, some intervention studies have shown no significant improvement. Zhang et al. (2020) reported that vitamin D supplementation had no significant effect on reducing systolic or diastolic blood pressure, based on a meta-analysis of 27 randomized controlled trials (RCTs) (Zhang et al., 2020). Similarly, Arora et al. (2015) concluded that vitamin D supplementation does not reduce blood pressure in pre-hypertensive or stage 1 hypertensive individuals with vitamin D deficiency. This double-blind RCT included 543 participants aged 18–50 years with vitamin D deficiency.

The optimal serum vitamin D level required for its protective effect against hypertension remains unclear. A meta-analysis by Mokhtari et al. (2022) found a U-shaped relationship between serum vitamin D levels and hypertension risk. In an analysis of 10 prospective studies, each 10 ng/mL (25 nmol/L) increase in serum vitamin D reduced the risk of hypertension by 5%, with the lowest risk observed between 45–70 nmol/L (18–28 ng/mL). Levels below 45 nmol/L (18 ng/mL) or above 70 nmol/L (28 ng/mL) were associated with increased risk. Similarly, an analysis of 56 cross-sectional studies revealed that every 10 ng/mL increase in serum vitamin D reduced hypertension risk by 6%, with the lowest risk between 40–75 nmol/L (16–30 ng/mL).

In contrast, Zhang et al. (2020) reported an L-shaped relationship, with hypertension risk increasing significantly when serum vitamin D levels fall below 75 nmol/L (30 ng/mL). Although the risk remains slightly elevated at levels between 75–130 nmol/L (30–54 ng/mL), it is less pronounced than at lower levels.

UVB levels peak between 10:00 a.m. and 3:00 p.m., while UVA remains relatively stable throughout the day. Although both types of radiation can cause skin damage when overexposed, UVB is more hazardous due to its carcinogenic potential and greater efficacy in inducing sunburn compared to UVA.34

Vitamin D synthesis requires UVB radiation to break the B-ring of 7-dehydrocholesterol into pre-vitamin D_3, making the timing of sunlight exposure critical.35 Indonesia, as a tropical country, has a high UV index, particularly in East Nusa Tenggara, where UV levels can reach very high or extreme categories. Consequently, unprotected exposure during midday is unsafe. Therefore, sun exposure should be obtained in the morning to maximize the benefits of vitamin D synthesis while minimizing the risk of skin cancer from high UV indices (Jacoeb et al., 2020.

Strengths And Limitation

This study has several notable strengths. It is among the few investigations conducted in eastern Indonesia that specifically examines the relationship between serum vitamin D levels and hypertension, thereby providing valuable local epidemiological evidence in a tropical population. The study focused on government employees—a population group with a high prevalence of hypertension—making the findings relevant for targeted public health interventions. The use of the Enzyme Chemiluminescence Immunoassay (ECLIA) method ensured precise and reliable measurement of serum vitamin D levels, and the application of standardized diagnostic criteria based on the 2020 International Society of Hypertension

guidelines enhanced methodological rigor. Nevertheless, the study has certain limitations. Its cross-sectional design precludes establishing causality between vitamin D levels and hypertension, and the relatively small, occupation-specific sample may limit generalizability. Several potential confounders such as diet, physical activity, and sunlight exposure were not fully controlled, and secondary hypertension was not excluded through further diagnostic testing. Future research should employ longitudinal or interventional designs with larger and more diverse populations, incorporate biochemical and behavioral covariates, and explore genetic or environmental factors influencing vitamin D metabolism to clarify its causal role in hypertension.

CONCLUSION

In conclusion, this study demonstrated a significant difference in serum vitamin D levels between government employees with hypertension and those without hypertension. Respondents with hypertension exhibited lower mean vitamin D levels compared to non-hypertensive individuals, and this difference was statistically significant ($p < 0.05$). These findings indicate a potential association between lower vitamin D status and the presence of hypertension among government employees in Kupang City, even after considering relevant confounding factors such as age and body mass index. Overall, the results support the growing evidence that vitamin D may play a contributory role in blood pressure regulation and cardiovascular risk profiles among adult populations.

For future research, longitudinal or cohort-based studies are recommended to better establish causal relationships between serum vitamin D levels and the development of hypertension. Expanding the sample size and including more diverse occupational and geographic populations would improve generalizability. In addition, future studies should incorporate more comprehensive control of confounding variables such as dietary intake, physical activity, sun exposure behavior, and genetic factors influencing vitamin D metabolism. Interventional studies, particularly randomized controlled trials examining the effect of vitamin D supplementation on blood pressure outcomes, are also needed to clarify its therapeutic potential and determine optimal serum vitamin D thresholds for cardiovascular protection.

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